Artemia, a New Source of Animal Protein Ingredient in Poultry Nutrition

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1. Introduction

In the nutritional behavior of single stomach animals, the origin of protein is important and its quality varies between different sources and animal origin is better than plant origin [7]. From the standpoint of salmonella contamination and due to high microbial potential, however, some of these proteins such as meat and bone meal ought to be used with caution. If heat treatment is not enough during fish meal processing, thiaminase will remain in fish meal and will cause harmful effects .Some researches indicated that thiamin will be reduced by thiaminase under special storage condition of ingredient before feeding animal [6,7] . Also, severe heating during meat and bone meal and fish meal processing to be confident that poultry by-product is safe, however some amino acids will probably degenerate and their bioavailability will decrease [5,7, 8,9] .

Although, meat & bone and fish meal have been used in poultry feeding, exclusively, but artemia biomass is also one of the animal proteins with high nutritional value which can be used in aquaculture and animal nutrition [1,4] .

The aim of this study is a survey of biology and characteristics of artemia and possibility of its usage in poultry nutrition as a protein source.

2. What is artemia?

Artemia or brine shrimp belongs to the animal kingdom, phylum of *arthropoda* , subphylum of *crustacean*, class of *branchiopoda*, order of *anostraca*, family of *artemidae* and genus of *artemia*. Linnaeus (1758) and Leach (1819) called it "*Cancer salinus*" and "*Artemia salina*", respectively. The latter name is because of the effect of salinity on morphological growth and development of artemia. Two species of artemia in Iran are: *Artemia urmiana* and

Artemia parthenogenetica. The first is native of Urmia lake and the second was observed in 12 regions of artemia habitats in Iran.

Artemia spreads in tropical and sub tropical regions in saline environments of the world, and over 500 artemia regions are discovered around the globe. Nine species of artemia were recognized in these regions.

More than two million kilograms of dried cysts of artemia with 0.4mm diameter are transacted in world markets every year. It is used as an aquaculture feed for hatched naplius. Uniformity of cysts and embryos with diapose has made artemia a unique source of aquaculture feeds. Artemia cysts can spread by wind and migratory birds.

Artemia contains 40-60% crude protein (dry matter basis) [11] .

3. Morphology and ecology

Morphologically, artemia has fragmented body with leave and wide shaped appearance. It's body consists of three compartments; head, thorax and abdomen, with total length of 8-10 mm and 10-12 mm in male and female respectively (Figure 1). Width of body is 4mm in both sexes. The exoskeleton of artemia is extremely thin (0.3-1μ) and flexible that called" chitin" and it is connected to muscle from inner surface.

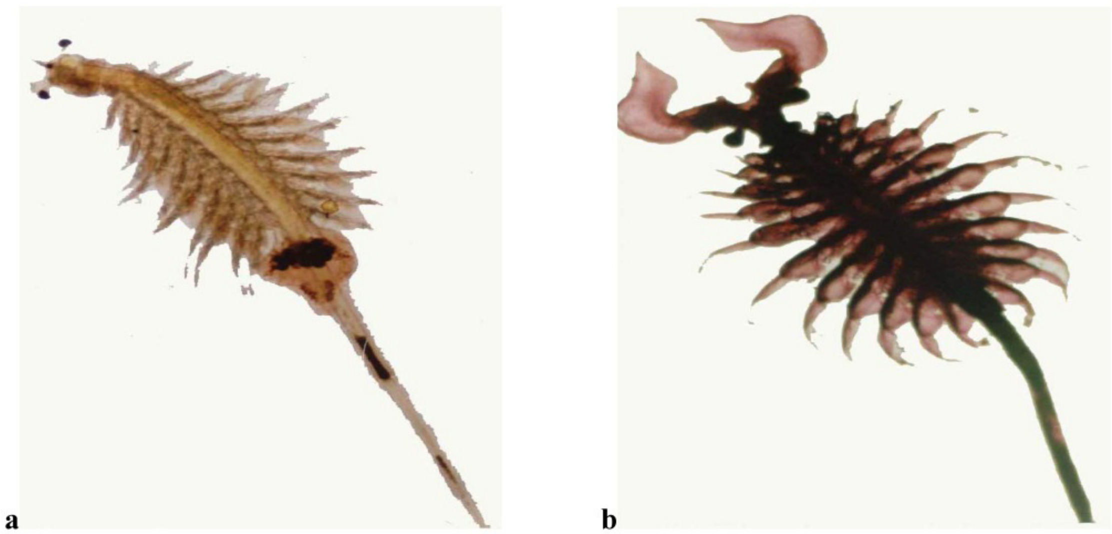

Figure 1. Artemia morphology a) female and b) male

The blood circulatory system of artemia is open.

This animal is euryhalin and can tolerate high concentration of salty habitat. There is a glandular organ in back of artemia neck that named; "salt gland" or "neck organ" .This organ exudates extra salt from the body to environment. Salty organ extinct at maturity and then this function is performed by exopodits of legs.

Although there are some limitations in the living environment of artemia, like high temperature and high salinity and drought, this animal can tolerate these conditions by producing cysts and going to diapose until the condition become suitable, and then it will continue its living.

Salinity and temperature are two important factors for growth and survival of artemia.

Artemia can tolerate salinity even more than 250 g/l and suitable range of temperature is 6-35°C.This crustacean has adapted itself with hard environmental conditions. In hypoxia, artemia increases the oxygen carrying capacity through the increase of the amount of hemoglobin. In this situation, body color turns red from original pale brown.

Physiological adaptation of artemia in high salinity is an effective defense method against predators using following mechanisms:

1. A powerful and effective osmoregulation system
2. Overcome high hypoxia in high salinity condition by higher pigmentation (inhalation pigments)
3. Production of embryos in diapose stage in cysts that can tolerate environmentally unfavorable condition.

4. Nutrition

From nutritional standpoint, artemia is non- selective filter feeder, and eats algae, bacteria, protozoa and yeasts, as long as feed particles diameter is not over 50-70 μm. Artemia feed can be alive or dead in artificial culture system. Artemia can uses bacteria and protozoa as feed sources, which grow in artemia culture medium. This protozoa (such as; *Candida, Rhodotorula*) can also be directly swallowed by artemia. The best algae's for artemia nutrition includes: *Dunaliella salina*, *Spirulina* and *Scenedesmus*. For artemia culture, agricultural products can be utilized such as; rice, corn, wheat, barley flours and their bran.

5. Reproduction

All bisexual species holds 42 chromosomes (2n = 42). *A.persimilis* holds 44 chromosomes (2n = 44) and *Artemia partenogenic* is diploid, triploid, tetraploid and even pantaploid. As a general rule, artemia populations are defined on the basis of the number of their chromosomes. However, contrary to mammalian, female artemia is heterogametic [3]. Artemia is produced by two ways: sexual and parthenogenesis (development of a new individual from an unfertilized egg). The mature female ovulates each 140 hours.

According to strain of artemia or method of living, it selects one of the following conditions; oviparous or ovoviviparous. In suitable situation of rising, reproduction trend is as larvae production (ovoviviparous) and in unsuitable situation of growth (salinity >50gm/lit and oxygen <5mg/lit) oviparous will occur. In the latter condition, growth of embryo will stop and enters diapauses. In suitable saline and nutritional conditions, females can produce 75 naplius each day and over its lift cycle (50 days), it reproduces 10-11 times.

In extreme hypoxia, due to increasing hemoglobin production, the color of artemia will change from light brown to yellow and then red.

Artemia cysts are spread by wind and birds. Earth pond or region of high salty water is suitable for culture and reproduction of artemia.

6. Different kinds of artemia from the nutritional point of view

From the nutritional point of view ,different kinds of artemia are:

- Decapsulated cysts
- Newly hatched nauplii
- Metanauplii and juvenile and adult
- Frozen and freeze – dried artemia

These forms of artemia are commonly used for newly hatched shrimps, sturgeons, trout, aquarium fishes and some crustaceans. Artemia biomass (consist of cysts and different living stages of artemia) is a suitable protein resource for other animals like poultry that consists of different stages of artemia growth.

7. Methods of artemia harvesting

According to artemia habitat, different biomass harvesting is utilized. In breeding pools and lake beaches, artemia is collected using a lace net that is fastened to two large floaters from each side (figure 2).

Because of phototropism characteristic, artemia can be collected easily by light source at night.

After harvesting, artemia biomass can be dried and cured under sunlight (Figure 3). Then the dried artemia will be milled before using in poultry diet.

Figure 2. Artemia biomass harvest

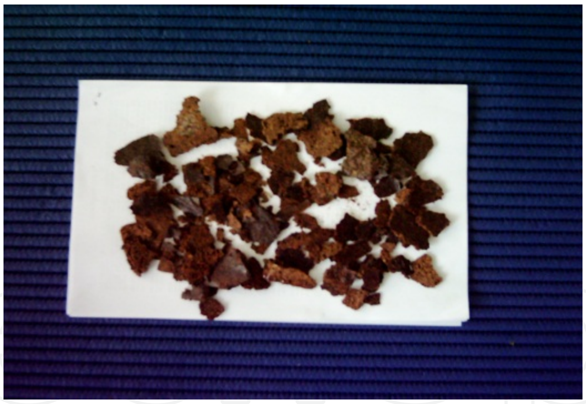

Figure 3. Flaked artemia

8. Chemical composition of artemia meal

The chemical composition of different kinds of artemia meal (dried at 50-60°C as sun cured or oven dried) is shown in Table 1. As shown in table 1, the chemical composition of 3 kinds of artemia meal (collected from different regions of Iran) is not identical. The quality of those ,depends on region, species, time of harvest and percentage of artemia mixture (artemia in different stages of living shows different compositions). So prior to using this ingredient, it must be analyzed for main nutrients.

Chemical composition		Kind of Artemia meal		
		ULAM	EPAM	GSLAM
Dry matter	g/kg	928	924	938
Crude Protein	g/kg	401.9	390.8	423.5
Gross Energy	MJ/kg	16.86	16.32	14.98
Crude Fat	g/kg	136	85.5	206.5
Crude Fiber	g/kg	36	18	28
Crude Ash	g/kg	240	287	284
Calcium (Ca)	g/kg	23.4	20.2	26.1
Phosphorus (P)	g/kg	11.1	8.6	14.2
Sodium (Na)	g/kg	12.1	9.6	16.4
Magnesium (Mg)	g/kg	3.3	4.1	3.1
Potassium (K)	g/kg	16.5	20.9	13.9
Iron (Fe)	mg/kg	1147.25	1642.75	437.75
Manganese (Mn)	mg/kg	53.78	132.45	84.08
Copper (Cu)	mg/kg	3.5	3.55	5.05
Zinc (Zn)	mg/kg	52.75	46.75	59

1- Zarei,A (2006) ,2- Urmia Lake Artemia Meal , 3- Earth Pond Artemia Meal , 4- Ghom Salt Lake Artemia Meal

Table 1. Chemical composition of three kinds of artemia meal (ULAM[2], EPAM[3], GSLAM[4]) (as g/kg , MJ /kg or mg/kg – DM basis)1

9. Metabolizable energy of artemia meal

An experiment was designed to determine different classes of metabolizable energy (AME, AMEn, TME, TMEn) in artemia meals [13] .For determination of metabolizable energy of artemia meal and comparison with fish meal, samples gathered from 3 regions include : Urmia Lake Artemia Meal(ULAM), Earth Ponds Artemia Meal (beside urmia lake)(EPAM) and Ghom Salt Lake Artemia Meal(GSLAM). Then samples dried, milled and used in a biological experiment with fish meal. 20 Rhode Island Red cockerels with approximately same live weight used in Sibbald assay with completely randomized design with 5 treatments and 4 repetitions for determination of AME, AMEn, TME and TMEn.

Results showed there were significant differences between treatments from standpoints of metabolizable energy ($P<0.05$). ULAM and FM had highest ME and EPAM and GLAM had lowest ME. The highest TME belong to FM and the lowest TME pertained to EPAM. Except to EPAM that had the lowest TMEn, other treatments didn't have any differences between them.

10. Protein and amino acids digestibility of artemia meal

Result from *in vitro* and *in vivo* experiments showed that this ingredient has high quality of protein and the amount of digestibility was more than 90% [12] .

In order to determination of artemia meal's amino acid digestibility, five-week old male broiler chicks were given a semi-purified diet in which artemia meal was the sole source of protein. Apparent amino acid digestibility values of the assay diet, using ileum and excreta contents, were calculated using chromic oxide as indigestible marker. True digestibility values were calculated using endogenous output determined by feeding a nitrogen-free diet. The results showed (Table 2) that in determination of apparent amino acid digestibility of excreta, serine had the lowest (0.80) and methionine had the highest (0.92) digestibility, while glycine had the lowest (0.88) and arginine and leucine had the highest (0.95) apparent ileal digestibility. In measuring true excreta and ileal amino acid digestibility, alanine and glycine had the lowest (0.90 and 0.93) and methionine had the highest (0.96 and 0.99) digestibility, respectively. In general, the site of measurement had no effect on apparent or true amino acid digestibility of artemia meal [2] .

11. Artemia meal in broiler diets

In another experiment, different levels of protein from two kinds of artemia meal include artemia meal from Urmia lake and artemia meal from earth ponds beside Urmia lake with levels of 0, 25, 50, 75, 100 percent replaced to prue fish meal protein [12]. The experimental design was completely randomized with factorial method; include 10 treatments and 3 repetitions that in each repetition there were 10 one day-old male broilers from Ross 308 strain. This experiment was performed in 7 weeks and during and end of it, traits that related to broiler performance and carcass, was measured and analyzed. Results showed that effect of kind of artemia meal and effect of level of protein replacement weren't significant for feed intake. But interaction between these two was significant for this trait ($P<0.05$). The highest feed intake belong to Urmia lake artemia meal treatment with 50% level of replacement and the lowest feed intake related to treatment of without artemia meal (contain 5% fish meal). For body weight gain and feed conversion ratio, effect of kind of artemia meal and effect of level of protein replacement and effect of interaction between these two weren't significant. These effects weren't significant for all carcass traits and gastro intestinal parts exception for femur percent that treatment of without artemia meal (contain 5% fish meal) had a lowest percent to comparison with other treatments for this trait.

Amino acids	Apparent digestibility				True digestibility			
	Excreta	Ileal	SEM[1]	P[2]	Excreta	Ileal	SEM	P
Methionine	0.92	0.94	0.004	NS	0.96	0.99	0.004	0.09
Lysine	0.88	0.92	0.007	NS	0.92	0.96	0.007	NS
Threonine	0.85	0.90	0.013	NS	0.93	0.98	0.011	NS
Tryptophan	0.88	0.94	0.014	NS	0.90	0.97	0.017	NS
Arginine	0.89	0.95	0.008	0.09	0.93	0.98	0.008	NS
Isoleucine	0.88	0.94	0.011	NS	0.92	0.98	0.011	NS
Leucine	0.89	0.95	0.009	0.06	0.94	0.98	0.009	NS
Valine	0.87	0.93	0.011	NS	0.93	0.98	0.010	NS
Histidine	0.89	0.93	0.007	NS	0.95	0.97	0.007	NS
Phenylalanine	0.87	0.94	0.009	0.09	0.92	0.97	0.009	NS
Glycine	0.81	0.88	0.015	NS	-	0.93	-	-
Serine	0.80	0.89	0.018	NS	0.91	0.97	0.017	NS
Alanine	0.85	0.91	0.014	NS	0.90	0.94	0.014	NS
Aspartic acid	0.86	0.91	0.010	NS	0.91	0.94	0.005	0.09
Glutamic acid	0.87	0.93	0.014	NS	0.93	0.95	0.013	NS
Total	0.85	0.92	0.010	0.09	0.94	0.96	0.011	NS
CP(N×6.25)[3]	0.81	0.89	0.013	NS	0.89	0.94	0.012	NS

NS – Non Significant ; [1]- Standard Error of Mean ; [2] – Probability ; CP- Crude Protein ;N – Nitrogen [3] – The values (protein digestibility) were not corrected for uric acid.

Table 2. Apparent and true digestibility (coefficients) of artemia meal determined by sampling either excreta or ileum contents

12. Conclusion

Results of this studies revealed that artemia meal can be used as a feedstuff in poultry and other farm animal's diets because it has high level of protein and high protein digestibility. Compared with other animal proteins, artemia does not contain any feather, bone, hair or gastrointestinal tract components. In addition, in artemia production there is no requirement for high pressure and high temperature treatments which can influence protein quality. Artificial culture of artemia is easy and is possible everywhere.

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